

MARS ROVER SAMPLE RETURN: AN EXOBIOLOGY SCIENCE SCENARIO;  
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A mission designed to collect and return samples from Mars will provide unique information regarding its composition, history, and evolution. At the same time, a sample return mission generates a technical challenge. Sophisticated, semi-autonomous, robotic spacecraft systems must be developed in order to carry out complex operations at the surface of a very distant planet. We have been conducting an interdisciplinary effort to consider how such a Mars mission can be realistically structured to maximize the planetary science return. Our focus has been to concentrate on a particular set of scientific objectives (exobiology), to determine the instrumentation and analyses required to search for biological signatures, and to evaluate what analyses and decision making can be effectively performed by the rover in order to minimize the overhead of constant communication between Mars and the Earth. We have also begun investigations in the area of machine vision to determine whether layered sedimentary structures can be recognized autonomously, and preliminary results are encouraging.

Investigations have shown that primordial Mars was similar to primordial Earth in many ways that are important to biological systems. Both planets were characterized by the presence of liquid water at the surface, an atmosphere of carbon dioxide and nitrogen, moderate surface temperatures, and high geothermal heat flow. These conditions are conducive to the formation of organic molecules that are thought to be the key to forming the first biologic molecules on Earth. Although there are no indications that extant life forms exist on the cold, dry, and chemically reactive surface of Mars today (1,2), the similar environments of early Earth and early Mars and the biological evolution that we know occurred on early Earth motivate serious consideration for the search for a primordial martian biosphere.

Since we know that water is the key to life on Earth, it is logical to explore areas on Mars where water may have existed for long periods of time. In our study, we have focused on the putative lake deposits in the equatorial canyons of the Valles Marineris where long-lived lakes may have once existed early in Mars' history. These deposits form plateaus of horizontally-layered material where individual layers are laterally continuous over tens of kilometers (3). Nedell *et al.* (3) concluded that deposition in standing water was the only mechanism that could readily explain the distribution, lateral continuity, horizontality, great thickness, and rhythmic nature of the deposits. The most important biological signatures to detect would be organic material, microfossils, or larger stromatolite-like structures, although the presence of carbonates, cherts, clays, and shales would also be significant. These traces of extinct biota and sedimentary deposits are all associated with liquid water.

The round-trip light time to Mars varies from 6.5 minutes during the most favorable opposition to 44.5 minutes when Mars is near solar conjunction, and communication may be regularly impossible. In addition, communication bandwidth will be a limiting resource. With these limitations in mind, we have developed a partial scenario to implement an exobiologic investigation patterned after the procedures of a field scientist. Only a limited number of small samples can be brought back from Mars and, therefore, it is most expedient to do as much of the analyses as possible insitu. We have considered survey procedures for the rover at the landing site, how to detect an

outcrop and a suitable sampling site for exobiologic investigations, and how to select and analyze a sample. Instruments needed will include: infrared spectrometer, active seismic instrument, XRF, GC, and various drills, corers, etc.

We have attempted to quantify the benefits and risks of rover autonomy. Our scenario has shown that we can minimize the amount of data that must be sent back for interactive decision-making, and therefore, much time is saved by the rover doing some rudimentary interpretations. As part of a collaborative effort with SRI's vision group, we have determined that sedimentary layering can be recognized by using fairly standard mathematical techniques. This is the type of automation tool we are currently investigating, which is designed to aid, not replace the Earth-based scientist. By developing a semi-autonomous rover, the scientific productivity of a Mars Rover Sample Return Mission will be increased.

#### REFERENCES

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